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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/820,694	03/30/2001	Helen H. Zhu	015290-502	7374

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EXAMINER
MALDONADO, JULIO J

ART UNIT	PAPER NUMBER
2823	

DATE MAILED: 06/05/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

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Office Action Summary	Application No.	Applicant(s)	
	09/820,694	ZHU ET AL.	
	Examiner	Art Unit	
	Julio J. Maldonado	2823	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *11 March 2003* .

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-23* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-23* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

1. The final rejection as set forth in paper No.9 is withdrawn in response to applicants' amendments.

2. A new rejection is made as set forth in this Office Action.

3. Claims 1-23 are pending in the application.

Continued Examination Under 37 CFR 1.114

4. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 03/11/2003 has been entered.

Claim Rejections - 35 USC § 103

5. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

6. Claims 1-23 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hung et al. (U.S. 6,380,096) in view of Kim et al. (U.S. 6,362,109 B1).

In reference to claim 1, Hung et al. (Figs.2-10) in a related method to perform a plasma etching to a silicon nitride layer for a copper damascene teach the steps of introducing a semiconductor substrate (10) into a plasma etching reactor (Fig.2), the

semiconductor substrate (10) having a layer of silicon nitride (12, 16) and the layer of silicon nitride (12, 16) having an underlying and/or overlying dielectric layer (14, 20); supplying etching gas to the plasma etching reactor and energizing the etching gas into a plasma state, the etching gas including at least one fluorocarbon reactant and at least one oxygen reactant supplied to the plasma etching reactor at a flow rate ratio of oxygen reactant to fluorocarbon reactant of 1.5 or less; etching the exposed portions of the silicon nitride layer (12, 16) with the plasma so as to etch openings in the silicon nitride layer (12, 16) with the plasma while providing an etch rate selectivity of etching rate of the silicon nitride layer (12, 16) to the etching rate of the dielectric layer (14, 20) (Figs.6 and 8) (column 8, line 27 – column 12, line 4). Hung et al. also teach optimizing the pressure of the reactor (column 12, lines 29 – 34).

Hung et al. fail to expressly teach that the rate selectivity of the nitride layer to the etching of the dielectric layer is at least about 5 or 10. However, the parameters used for etching the silicon nitride (e.g. etchant flow rate, bias power, pressure and temperature) layer falls in those of the claimed invention. The recited results would be obtained because the same materials are treated in the same manner as in the instant invention. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to arrive at the recited etch selectivity of the nitride layer with respect to the selectivity of the dielectric layer.

Still, Hung et al. fail to teach using a medium density plasma-etching reactor. However, Kim et al. (Figs.1-3) in a related method to form a high-aspect ratio hole teach etching silicon nitride and silicon oxide in a medium density plasma reactor (40) (column

4, line 43 – column 6, line 26). Alternatively, Kim et al. teach performing said etching process on a high density plasma etching reactor as obtaining equivalent results to the medium density plasma reactor (column 7, lines 20 – 23). Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to etch the silicon oxide layer and the silicon nitride layer as taught by Kim et al. in the plasma etching process of Hung et al. (Figs.5 and 6), because this would allow the formation of high-aspect ratio interconnects and high selectivity over other layers formed on the substrate (column 4, lines 11 – 30).

In reference to claims 2-12, Hung et al. teach that the dielectric layer (14, 20) comprises an undoped silicon oxide (column 2, lines 30-35); the at least one fluorocarbon reactant is represented by $C_xF_yH_z$, wherein x is at least 1, y is at least 1 and z is equal to or greater than 2 (column 11, lines 52-56); the etching gas is nitrogen-free and the flow rate ratio of the oxygen reactant to fluorocarbon reactant is 1 or less (10/10 sccm for O_2/CH_2F_2 and 5/30 sccm for O_2/CH_3F) (see Hung et al. table 6-7); the etching gas consists essentially of CH_3F, oxygen and optionally argon as a carrier gas (see table 7); the silicon nitride layer (12, 16) overlies or underlies an organic low-k dielectric material (column 13, lines 12-20); the openings are 0.25 micron or smaller sized openings and/or via wide open trenches (column 13, lines 2-6); and the plasma reactor (Fig.2) comprises a dual frequency parallel plate plasma reactor having a showerhead electrode and a bottom electrode on which the substrate (10) is supported, the bottom electrode being supplied RF energy at two different frequencies or the showerhead electrode being supplied RF energy at a first frequency and the bottom

electrode being supplied RF energy at a second frequency which is greater than the first frequency (column 3, lines 42-65).

In reference to claims 13-15, Hung et al. teach applying an RF bias to the semiconductor substrate (10) during the etching step (see table 6); overlying the silicon nitride layer (12) over an electrically conductive layer (11) comprising a copper or aluminum (column 8, lines 30-35); wherein the etching step is carried out as part of a process of manufacturing a damascene structure (see Figs.3-10).

In reference to claim 16, Hung et al. teach the steps of forming a photoresist layer as a masking layer (98), patterning the photoresist layer to form a plurality of the openings and the etching step forms via or contact openings (104) in the silicon nitride layer (12, 16).

In reference to claims 17-19, Hung et al. teach that the silicon nitride layer (12) is between an overlying dielectric layer (14) and an underlying copper layer (11), the copper layer (11) being exposed to the plasma in the openings during the etching step (column 11, line 48 – column 12, line 4); that the fluorocarbon reactant is a hydrogen-containing fluorocarbon and the etching gas supplied to the plasma reactor does not include nitrogen as a component thereof (see table 6); that the plasma reactor (Fig.2) is at a pressure of 15mTorr during the etching step (see table 6); and the semiconductor substrate (10) comprises a silicon wafer supported on a bottom electrode and the bottom electrode is maintained at a temperature of 15°C during the etching step (see table 5).

In reference to claim 20, Hung et al. fail to show that the temperature of the bottom electrode is maintained at a temperature of 20 to 50°C during the etching step. However, The selection of the claimed range is obvious because it is a matter of determining optimum process condition by routine experimentation with a limited number of species. In re Jones, 162 USPQ 224 (CCPA 1955)(the selection of optimum ranges within prior art general conditions is obvious) and In re Boesch, 205 USPQ 215 (CCPA 1980)(discovery of optimum value of result effective variable in a known process is obvious).

In reference to claims 21 – 23, Hung et al. in combination with Kim et al. teach using a reactor comprising a capacitively coupled plasma reactor at a pressure above 80 mTorr, wherein the fluorocarbon reactant is supplied at a flow rate of 20 to 40 sccm and the oxygen reactant is supplied at a flow rate of 20 to 40 sccm (Kim et al., column 6, lines 5 – 31).

Response to Arguments

7. Applicant's arguments filed 03/11/2003 have been fully considered but they are not persuasive.

Applicants' argue that Kim teaches away from the claimed invention because Kim teaches a single step plasma etching process for etching both oxide and nitride with selectivity to photoresist and silicon. In response to this argument, although applicants' assert the above-mentioned teachings in Kim, Kim was relied on performing

plasma-etching processes using either a medium density plasma reactor or a high-density plasma reactor.

Conclusion

8. Papers related to this application may be submitted directly to Art Unit 2823 by facsimile transmission. Papers should be faxed to Art Unit 2823 via the Art Unit 2823 Fax Center located in Crystal Plaza 4, room 3C23. The faxing of such papers must conform to the notice published in the Official Gazette, 1096 OG 30 (15 November 1989). The Art Unit 2823 Fax Center number is **(703) 305-3432**. The Art Unit 2823 Fax Center is to be used only for papers related to Art Unit 2823 applications.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to **Julio J. Maldonado** at **(703) 306-0098** and between the hours of 8:00 AM to 4:00 PM (Eastern Standard Time) Monday through Friday or by e-mail via julio.maldonado@uspto.gov. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Olik Chaudhuri, can be reached on (703) 306-2794.

Any inquiry of a general nature or relating to the status of this application should be directed to the **Group 2800 Receptionist** at **(703) 308-0956**.

JMR
6/2/03

George Fourson
Primary Examiner